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WASTES FROM THE POULTRY PROCESSING INDUSTRY

Ralph Porges, et al

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

1962

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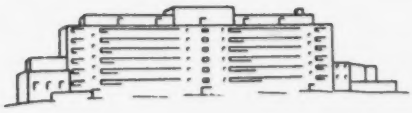

The Robert A. Taft
Sanitary Engineering Center
TECHNICAL REPORT
W62-3

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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WASTES FROM THE POULTRY PROCESSING INDUSTRY

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WASTE TREATMENT STUDIES
Ralph Porges
Sanitary Engineer Director, In Charge
Edmund J. Struzeski, Jr.
Senior Assistant Sanitary Engineer

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Division of Water Supply and Pollution Control
Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

1962

WASTE TREATMENT STUDIES

Waste Treatment Studies is an activity of the Field Operations Section, Technical Services Branch, Div. of Water Supply and Pollution Control of the Public Health Service.

Mr. Struzeski is now with the Colorado River Basin Project, Denver Colorado

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PREFACE

There is definite need for an understanding of the industrial processes, water demands, and waste discharges of many smaller types of manufactories. This need will grow as the limits of water resources are reached and as the practice of waste treatment is intensified for protection of downstream water users. Protecting our water resources is essential to health and economic growth. Stream pollution control provides benefits to industry, the individual citizen and the Nation. Since the most economical operation is achieved when process waste is at a minimum, it is particularly advantageous for industry to understand its waste problem.

The slaughtering and dressing of poultry is one of the smaller industries but nevertheless a very important one. Modern development has been towards centralization of poultry plants. In certain areas of the country where poultry processing establishments have concentrated, the problem of waste disposal is critical. Even one plant of average size or greater may pose a serious waste problem in a small town.

This study was undertaken because of the interest shown by regulatory agencies, industry, consulting engineers, and others concerned with water use and waste disposal. The primary intent of this report is to show suitable means of waste water utilization, reduction, and disposal. Although much of the information has been obtained from the published record, considerable data have been derived from field investigation and contacts with many people vitally interested in the poultry industry.

Process evaluation and waste treatment are subject to continuous change, and as new and better information becomes available, revised reports will be issued.

ACKNOWLEDGMENT

Excellent cooperation by personnel in various State Health Departments, the poultry industry, municipal agencies, Federal agencies including the U. S. Public Health Service and the Agricultural Marketing Service of the U. S. Department of Agriculture, and other organizations, was a major factor in making this report possible. Special recognition is given to Sanitary Engineer John Bolton of the State of Alabama Water Improvement Commission, who kindly reviewed the text and provided many of the pictures, and to Mr. Alfred J. Steffen, Manager of the Sanitary Engineering Research and Technical Division of Wilson and Company who offered helpful criticism and suggestions and provided pertinent data on recent poultry processing statistics and modern day practices employed by the industry. All photographs are used with permission of industrial sources. The assistance of these and all other individuals who aided in the study and preparation of this report is gratefully acknowledged.

SUMMARY

Poultry processing is a billion dollar industry. Approximately 7 billion pounds of chickens and 1.5 billion pounds of turkeys were processed during 1960. Nine southern States extending from Delaware to Texas produced about three-quarters of the commercial broilers and two-thirds of the farm chickens raised in this country.

The average poultry processing plant today is a modern, highly automatic establishment processing in the neighborhood of 50,000 birds per day. The larger plants may easily handle between 60,000 and 90,000 birds per day under normal operations and often exceed 150,000 birds per day.

The various operations at a poultry plant may be grouped under the general headings of receiving, killing, defeathering, evisceration and cutting, and packing. Ninety-five percent or more of all poultry are dressed as eviscerated pack.

The poultry when received are attached to shackles suspended from a moving overhead conveyor line where they remain from the time they leave the coops until they reach the chilling operation. After the birds are killed and bled, they are passed through a scald tank to loosen feathers and then through a series of automatically operated defeathering machines. Hand-picking and singeing operations remove the remaining pin feathers. After the birds are picked, they are washed and eviscerated, and the carcasses cleaned. Giblets and necks are recovered. The final steps of processing consist of chilling, sizing, grading, and packing. Birds for immediate shipment are ice-packed; others are enclosed in containers, frozen, and stored within the plant.

The blood from the killing station represents the waste of greatest pollutional significance. Defeathering and eviscerating operations account for a sizable portion of the total plant waste load; receiving and packing operations produce lesser amounts of wastes.

The large majority of poultry establishments have flow-away systems consisting of flumes or conduits to receive wastes and wash waters from feather picking and evisceration. Wastes from other areas of the plant are generally discharged to the flow-away systems. Solids are screened from the flow-away waste stream and collected in barrels or bulk-handled for separate disposal. Since a substantial flow of water is used in transporting discarded

wastes by flow-away systems, poultry plants utilizing this method have relatively high water demands. In poultry plants without flow-away systems, the feathers are collected from the picking area floor and evisceration offal is deposited in barrels.

Recovery of blood, feathers, and offal for by-product salvage or separate disposal significantly reduces the pollutional load in the processing waters. In most cases recoverable solids are sold to rendering companies or given to farmers, thereby minimizing disposal costs.

Unit waste loadings vary from one poultry plant to another. Representative values have been developed for the principal methods of processing.

Flow-away poultry plants use aaout 8,000 gallons of process water per 1,000 chickens. With reasonable recovery of blood, BOD and suspended solids per 1,000 chickens are approximately 25 and 13 pounds respectively. When all blood is wasted, BOD and suspended solids unit loads increase to 41 and 23 pounds respectively.

Poultry establishments without flow-away facilities discharge about 4,500 gallons of processing water per 1,000 birds handled. With reasonable blood recovery, BOD and suspended solids values per 1,000 birds are approximately 23 pounds and 12 pounds respectively. When all blood is flushed to the sewer, the unit BOD and suspended solids loads increase to 35 pounds and 21 pounds respectively.

Untreated poultry wastes have the following pollutional effects upon receiving streams: reduction of available oxygen, deposition of solids, addition of floating matter, and increase of coliform color, and inorganic mineral content.

Poultry wastes most often are discharged to municipal treatment facilities, since this is the most economical and trouble-free means of disposal. Poultry plants using municipal sewage systems are generally required to screen their wastes before discharge. In fact, poultry wastes should be screened before any subsequent treatment. Flow-away plants must screen feather and offal waters to remove solid wastes.

Liberal allowances for poultry wastes should be included in the design of municipal sewage treatment plants. Initial design criteria should encompass both peak and average loadings. A 16-hour discharge period for poultry processing establishments is reasonable for design purposes if sufficient reserve treatment

capacity is provided to allow for probable expansion of the poultry establishment.

Various methods are employed for treatment of poultry plant wastes. Grease can be removed by properly designed and adequately maintained traps. Primary settling removes much of the settleable solids. Chemical treatment has not shown promise; laboratory studies indicate that BOD and suspended solids removals fall into an intermediate treatment range. Coagulant dosages are high and treatment is expensive.

Trickling filters and the activated sludge process have not been widely used in poultry plants because of relatively high capital costs and the amount of operational care required. These methods provide 75 to 95 percent reduction of BOD and 90 to 95 percent reduction of suspended solids. The extended aeration modification of the activated sludge process is finding application in the treatment of poultry wastes. At one plant, 90 percent removal of BOD and 79 percent removal of suspended solids were reported after 6 months of operation.

Stabilization ponds have been used successfully for treating both poultry and combined poultry and domestic wastes. Loadings up to 50 pounds BOD per acre per day are common in some areas of the South. Ponds generally provide from 70 to 95 percent BOD reduction.

Treatment and disposal of poultry wastes by land irrigation is attractive because of low initial and operational costs. The major deterrent is the large acreage required.

WASTES FROM THE POULTRY PROCESSING INDUSTRY

INTRODUCTION

The crowing of the jungle cock, the "Gallus bankiva,"* is still heard in India.[1] From this bird have descended the fowls of the ancients of Persia, Egypt, Greece, and Rome. Chickens were abundant in Western Europe at the time the first colonists were making their way to the New World. The turkey, however, is an American Bird and was found here by the earliest settlers. Through the ages, the cock and hen first emerged as a timekeeper and watchdog and later became an important producer of food for the family. From so humble a beginning our billion dollar poultry industry has evolved.

Poultry are processed in every State. The regional distribution of poultry raising, shown in Figure 1 and Table 1, closely approximates the distribution of poultry processing across the country. The nine States of Delaware, Maryland, Virginia, North Carolina, Georgia, Alabama, Mississippi, Arkansas, and Texas produced approximately 73 percent of all commercial broilers and 67 percent of all chickens (i.e. commercial broilers and farm chickens) in the United States for the year 1960.[2] There is a strong indication that this area will show further gains in commercial broiler production. The North Central and Pacific States produced approximately 70 percent of all turkeys in 1960, with Minnesota, California, and Iowa leading with a combined total of 43 percent.[3]

The poultry industry has taken tremendous strides over the last few years. Processing plants have become larger and more centralized and rely on newer and faster equipment to provide a high degree of automation. Strict schedules are maintained for

Figure 1. 1960 U. S. Poultry Production

*Chickens that are marketed in the U. S. are named, "Gallus domesticus".

receiving and shipping. Consequently, the average poultry establishment today dresses, packs, and ships more birds in a shorter period of time. Major attention is given to the raising of broilers, since these birds can be fully grown and ready for processing within 7 to 9 weeks. This results in reduced costs for both the grower and the processor. The small retail processor who caters to individual tastes is becoming a reminder of the past.

The significant upward trend of the poultry industry is indicated by the quantity of chickens and turkeys slaughtered (Table 2). In 1947, 0.8 billion pounds of chickens (dressed weight) and 0.2 billion pounds of turkeys were slaughtered.[4] This is in contrast to the 2.6 billion pounds of chickens and 0.5 billion pounds of turkeys killed in 1954, and the 4.1 billion pounds of chickens and 0.9 billion pounds of turkeys handled during 1960.

Table 1. 1960 POULTRY PRODUCTION, BY REGION
(Live weights in millions of pounds)

Area	Broilers	Farm chickens
New England	351.3	81.5
Middle Atlantic	210.5	111.6
South Atlantic	2,632.7	118.3
East North Central	277.7	137.8
East South Central	1,100.7	43.1
West North Central	156.6	231.1
West South Central	982.1	58.2
Mountain	24.3	17.5
Pacific	284.5	103.8

In addition to chickens and turkeys, smaller quantities of other species of poultry were processed. Sixty-six million pounds (live weight) of ducks and 3.0 million pounds of geese were dressed for market in 1960.[5] These quantities have remained relatively constant over the last few years.[4, 5]

The gross annual income of poultry processors has risen from 0.4 billion dollars in 1947 to 1.1 billion in 1954[4] and to 1.52 billion in 1960. The 1960 gross income included 1.01 billion dollars from commercial broilers, 0.11 billion dollars from farm chickens, and 0.38 billion dollars from turkeys.[2, 3, 5]

This study relates poultry plant processes to water use and waste discharge and discusses the various waste treatment processes. It is based largely upon information derived from chicken processing plants since much of the available data refer to this type of poultry. More data on the processing of all kinds of poultry would be desirable.

Table 2. POULTRY PLANT PRODUCTION
(Dressed Weight in Millions of Pounds)

PRODUCT	1947[4]	1954[4, 9]	1958[4, 9]	1960[8]
Chickens				
Eviscerated or drawn	149.4	1,764.7	2,785.0	4,071.4[a]
New York dressed	605.7	841.1	633.0	-
Other	-	-	174.0	-
Turkeys				
Eviscerated or drawn	54.9	356.0	608.1	948.4[a]
New York dressed	161.6	111.5	91.2	-
Other	-	-	38.0	-

A. Excludes poultry not slaughtered at Federally inspected plants. Eviscerated poultry estimated to be 95 percent or more of total dressed weight of chickens and turkeys produced in 1960.[6, 7]

PLANT OPERATION

A poultry processing plant is a mechanized slaughterhouse in which live birds are converted to the dressed product for sale to distributors. The birds are received, killed, bled, plucked, cleaned, chilled, and packed in ice or frozen for shipment. Under present practices, approximately 95 percent of the birds are processed as eviscerated, or "ready-to-cook" poultry,[2, 6, 7] whereas most of the remainder are dressed as New York pack.

For the eviscerated pack, the feet, viscera, crop, neck, and head are removed; the neck and the giblets (heart, liver, and gizzard) are reclaimed, cleaned and replaced in the body cavity after it has been thoroughly cleaned. New York pack differs from eviscerated pack in that the bird, after it is defeathered, is packaged practically whole except possibly for removal of the head.

Eviscerated pack processing has increased greatly in the last few years (Table 2) to comply with Federal regulations (1958)[12] that provide for visual inspection of the viscera and interior of the carcass of poultry shipped interstate (or under voluntary inspection), and to meet consumer preference. Other factors accounting for the preponderance of eviscerated poultry are the Poultry Ordinance formulated by the U. S. Public Health Service in 1955,[10] and Supplement No. 1 to the Ordinance published by the U. S. Public Health Service in 1958.[11]

Significant provisions in the Poultry Ordinance are the recommendations that, for proper inspection of slaughtered poultry, each carcass shall be opened to expose the organs and body cavity; the viscera, exterior and interior of the carcass, and other portions shall be examined visually; and, interior parts shall not be removed until time of evisceration and post-mortem inspection. The Poultry Ordinance was formulated as a model that could be adopted readily and used by States, municipalities, and the industry to improve the wholesomeness of the product sold to the consumer.

The Federal Regulations of 1958 incorporated most of the provisions of the Poultry Ordinance of 1955 and specified additional procedures to be used at poultry plants. According to these regulations, interstate shipments of dressed poultry must be certified by the U. S. Department of Agriculture. This government agency provides personnel who inspect each bird before killing and upon evisceration. The poultry, if certified, receive the U. S. Department of Agriculture seal.

During 1960, 91.0 percent of all chickens and 99.5 percent of all turkeys processed were inspected by the U. S. Department of Agriculture.

Most commercial processing establishments handle from 5,000 to 90,000 birds per day; however, some may process more than 150,000 chickens in a single day. Chicken processing plants usually process more birds of greater total weight each day than turkey plants. Most poultry plants process only one kind of poultry; however, chicken plants, particularly the smaller plants, receive and dress relatively large numbers of turkeys during late fall. Chickens are generally processed at a fairly constant rate throughout the year,[2] although some plants process greater numbers during the summer months. The turkey plants have a seasonal peak in the fall. Few plants raise the birds they process.

The larger poultry processing plants normally operate 4 to 6 days a week on a daily schedule of 7 to 10 hours of processing followed by 5 to 9 hours of cleanup. A few of the large plants employ two 8-hour shifts for processing followed by third-shift clean-up. There is more variance in the daily schedule of small poultry plants, which frequently operate only 2 or 3 days a week.

The average weight of the live birds received by poultry processing establishments varies; however, any one plant receives birds of more or less constant average weight. According to Pennington:[1]

> "Chickens are birds of the hatch of the current year, not sexually mature and are classed as 'broilers' under 3 pounds, 'fryers' about 3 pounds, and 'roasters' 3 pounds up. 'Fowls' are hens which have laid eggs. Mature roosters are 'cocks'."

The above classification is perhaps somewhat outdated since the so-called "broilers," which comprise a great majority of the chickens raised today, range in live weight from 2.8 to 3.7 pounds.[2,5] "Farm" chickens received by poultry processing plants are mostly fowl (hens) that weigh between 4.5 and 5.0 pounds. U. S. Department of Agriculture statistics for 1960 show that the average weights of broilers and farm chickens raised across the country were 3.35 pounds and 4.77 pounds, respectively.[2] The average live weight of all chickens produced was 3.48 pounds.

With the greater numbers of broilers raised each year, the average weight of chickens marketed has decreased. The trend is toward an average weight of approximately 3.3 pounds.

The average weight of turkeys produced for market in 1960 was 17.84 pounds.[5] Ducks are ready for slaughter after approximately 8 weeks of growth to a weight between 5.5 and 6.5 pounds. The average live weight of all ducks sold on the market during the year 1960 approximated 6.2 pounds.[5] In this same year, the average weight of geese received by commercial poultry establishments was 10.4 pounds.[5]

DESCRIPTION OF PROCESS

The various poultry processing operations are grouped and discussed as follows: Receiving of live birds, killing, defeathering, evisceration and cutting, and packing. A line diagram typical of poultry processing operations is presented in Figure 2.

Receiving of Live Birds

Live birds in coops are unloaded from incoming trucks at the receiving area of the poultry processing plant and sent to the process line or to storage. Up to a few years ago, it was common practice to hold live birds in storage to accumulate sufficient numbers for continuous processing or to fatten or improve the birds by feeding. The poultry were loaded into wire batteries or cages and taken to a battery room, where they were watered and fed. Storage periods varied from 1 day to as long as 10 days.[14,15,16] Because poultry processors have found that storage is generally uneconomical, only a few establishments today provide facilities for the storage and feeding of live birds.

At the larger poultry houses with high production rates, poultry are moved almost immediately from the truck to the conveyor line (Figures 3 and 4). The schedule of incoming truck shipments is staggered so that the holding time of live birds on the trucks and during receiving is kept to a minimum. Smaller poultry dressing establishments may keep live birds on hand several hours before killing.

Upon removal from the coops, the birds are attached by their feet to shackles suspended from a moving, overhead conveyor line (Figure 4). The coops are returned to the trucks generally without being cleaned. One or more overhead conveyor lines serve the receiving and processing areas within the plant. The conveyors travel at a prescribed rate dependent upon the number of workers at the plant and the type of poultry handled. The birds are moved directly from the receiving area to the killing station.

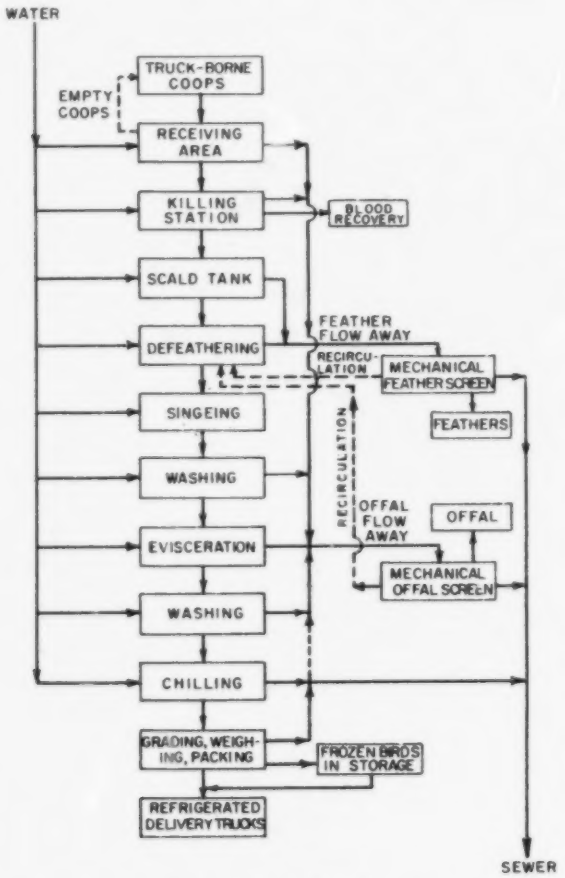

Figure 2. Flow Chart

Killing

Poultry are slaughtered by any one of several methods but usually by severance of the jugular vein or debraining as they pass the killing station (Figure 5). The killing area is generally enclosed to restrict the drainable blood to this part of the plant (Figure 6).

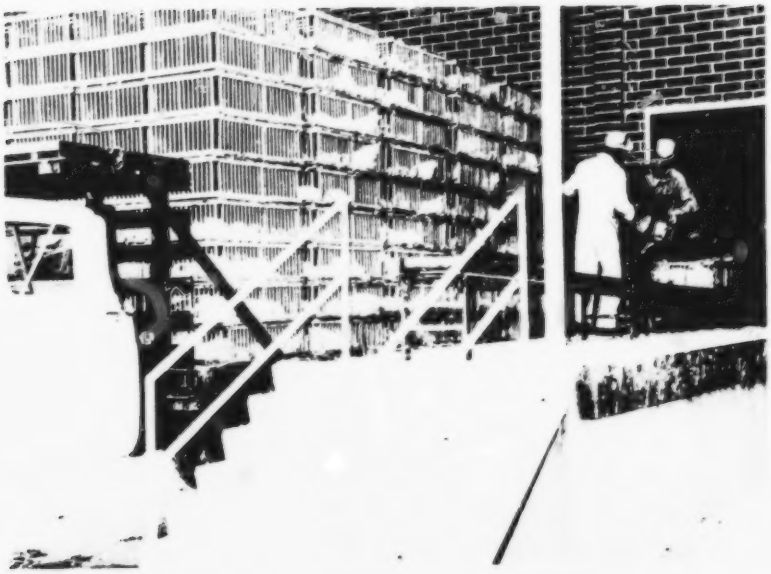

Figure 3. Unloading Live Poultry

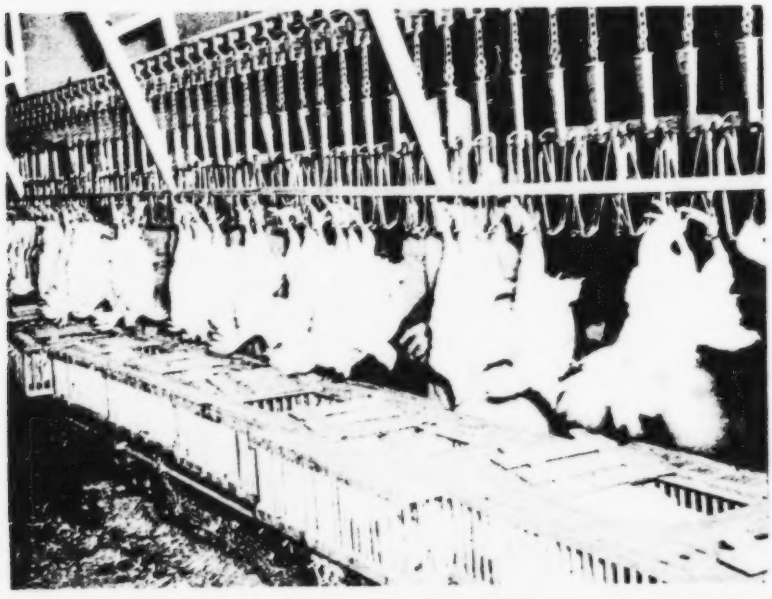

Figure 4. Attaching Birds to Conveyor

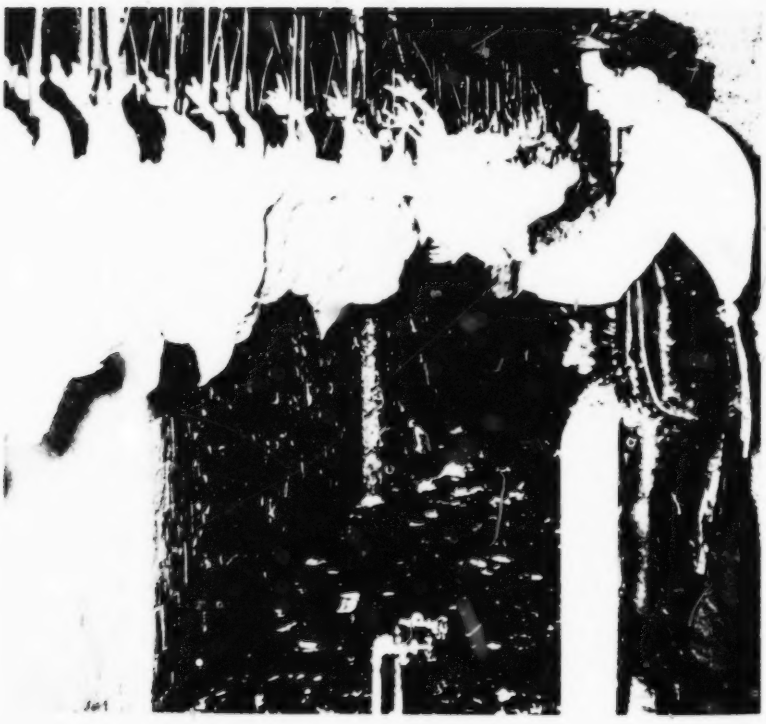

Figure 5. Killing Station

Defeathering

After the poultry are killed and the blood drained, they are scalded with hot water either by immersion in scald tanks (Figure 7) or by spray scalds, to loosen feathers. Scald tanks are more widely used than the spray scald. The temperature of the water is dependent upon the type of scald: for low-temperature scalding the water is maintained at approximately 128°F, and for high-temperature scalding around 140°F.

Feathers are removed mechanically following scalding. Line defeathering machines, which are continuous in operation, are more popular than batch-operated cyclic-type machines because of greater output and flexibility (Figures 8 and 9). The line-type also requires less labor because with the cyclic-type machine the birds have to be removed from the line by hand, placed in the machine, and subsequently replaced on the line. The number and kind of line machines used (roughers, strippers, and pickers) depend upon the type and size of bird and the specific parts to be cleaned. Roughers and pickers used most commonly consist of counter-rotating steel drums with mounted rubber "fingers."

Strippers rely on the action of counter-rotating drums for the removal of feathers. Continuous water sprays are generally incorporated within these machines for flushing out feathers. A flow-away system is used by most plants for transporting feathers and dirt from the defeathering machine area.

Pin feathers are removed next, usually by hand. A small number of plants utilize wax stripping. In this process the birds are dipped in a bath of molten wax and passed through cold water sprays. The hardened wax is stripped from the birds and in the process pin feathers are removed. Wax is reclaimed for re-use although some may inadvertently escape to the sewer.

After the pin feathers are removed, the birds are passed through an arc-gas flame to singe remaining fine hair and pin feathers. They are then washed in an "outside washer," which in most cases is a self-contained, continuously running spray device.

Most of the plants that use wax stripping are duck processing plants. In these plants a double-stripping operation is usually followed by scalding, eliminating the need for singeing. Singeing is not practical because the ducks have a relatively high fat content and readily "run" when exposed to flame. The scalding following the double-stripping operation loosens any remaining hair and pin feathers for hand-picking.

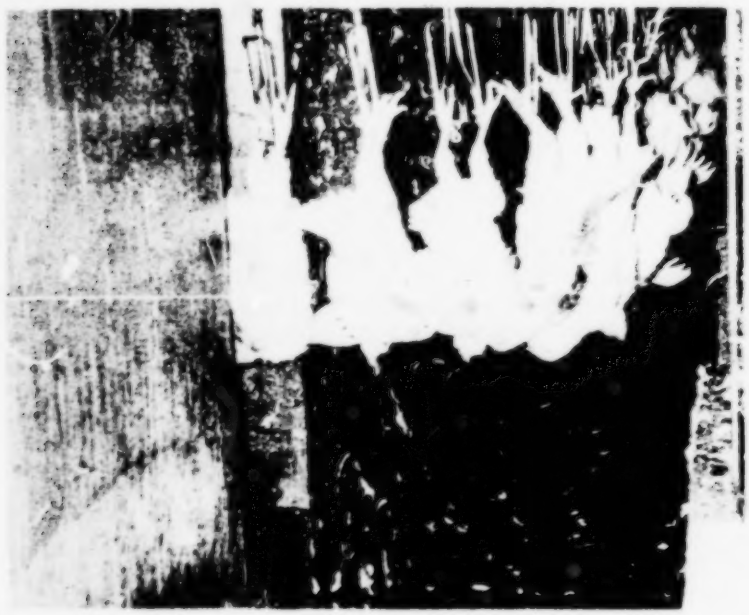

Figure 6. Bleeding Area

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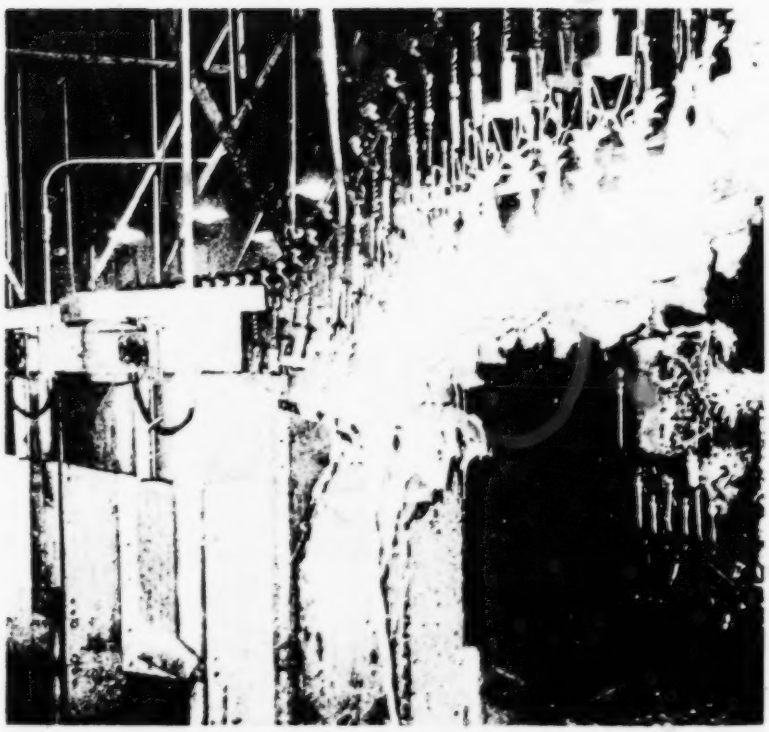

Figure 7. Poultry Leaving the Scald Tank

Evisceration and Cutting

The evisceration room is completely enclosed and is segregated from the remainder of the plant to insure that eviscerated poultry do not come in contact with the wastes from previous operations. In addition to its use for evisceration and cutting, this room is used for preparation of specialty packs, and chilling and packing dressed poultry. As the poultry reach the evisceration area, the lower leg portion is removed. The birds are then trussed on the conveyor line, by either two- or three-point suspension, to facilitate removal of the viscera. Subsequent eviscerating operations include removal of the oil gland; the first incision; pulling of the entrails and other inner organs; inspection of the carcass and interior parts by personnel of the U. S. Department of Agriculture; recovery, trimming, and washing of the heart, liver, and gizzard; discard of inedible viscera, removal of the lungs and any other remaining material within the carcass, by suction, raking, or by hand; removal of the head; and recovery and washing of the neck. Gizzard cleaning requires four steps:

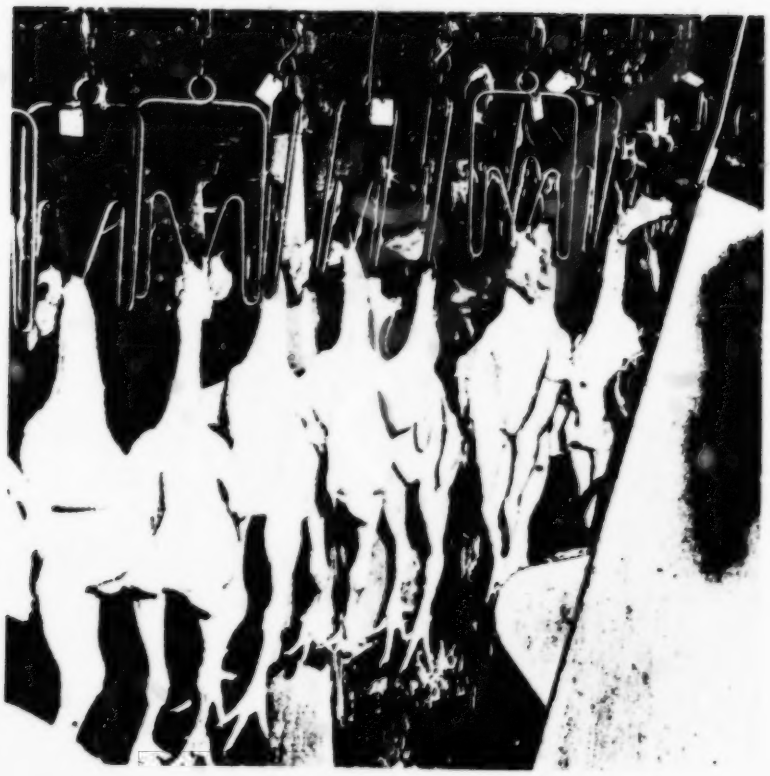

Figure 8. Mechanical, Line-Type, Defeathering Machine

splitting, washing out the contents, peeling of the outer cover, and the final wash.

The offal flow-away system deserves special mention because it has become a vital part in eviscerating room procedures. Most of the poultry processing establishments employ offal flow-away for convenience in handling and disposing of evisceration wastes. In this system a central flume generally is incorporated within the evisceration table and serves as a receptacle for discarded solids. Water from taps on the evisceration table flows continuously into the flume and carries the discarded wastes to screening facilities within the plant.

After evisceration the birds are thoroughly washed in an "in-side washer," which automatically spray-washes the interior of the bird.

If desired, the carcasses may be cut up further and packaged or processed as specialty packs (wings, breasts, legs, etc.), and the giblets may be used in giblet packs.

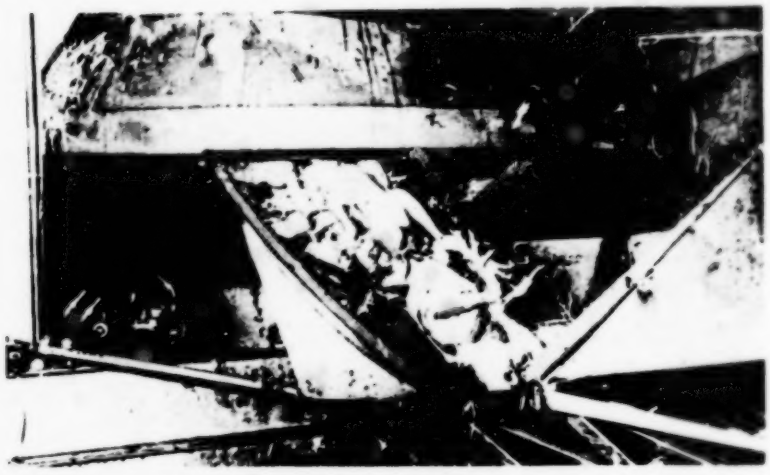

Figure 9. Mechanical, Cyclic-Type, Defeathering Machine

Packing

Cleaned and processed poultry are chilled, and sometimes frozen, before shipment. The removal of animal heat is an important operation. Not only is flavor improved by a thorough and rapid chilling, but length of marketing life is increased. [1]

Many of the modern poultry dressing establishments rely on large mechanically-driven horizontal tanks for quick-chilling (Figures 10 and 11). One method of quick-chilling is spin-chilling in a rotating metal cylinder-type chill tank containing ice and water. There are two versions of this rotary chill tank. In one case the entire unit consists of an enclosed drum rotating on a horizontal axis. The other is a rotating, cylindrical metal shield mounted within an open chill vat. The cylinder is perforated to permit free movement of water. A third type of mechanically-driven chill tank also in common use consists of a large open vat set on a base specifically designed to impart a rocking motion to the tank. The birds are drawn through the tank by automatic raker arms.

In practice, a large poultry plant utilizes two or three mechanical-type chill tanks in series for carcasses and a series of smaller tanks for giblets. Refrigerated or iced water is added to the first unit to reduce the carcass temperature to approximately 65°F; ice is added to the water in subsequent chill tanks. There may be counter-current recirculation of water and ice within each unit, but a certain amount of overflow from the chilling cycle is required. By use of the above innovations, eviscerated poultry can be quick-chilled to around 34°F. in 30 to 35 minutes.

Many plants do not have mechanical equipment for quick chilling and simply place the birds, giblets, etc., into portable vats or tubs to slow chill by immersion in water and ice. Cut-up parts generally are chilled in this way.

After the birds are chilled, they are replaced on the conveyor line to allow excess moisture to drain off. The poultry are thereafter "sized" into appropriate weight categories automatically or manually, and then graded and packed. If the birds are to be frozen, they are generally enclosed within suitable containers or wrappers. The great majority of birds are "ice packed" in cracked ice in wooden crates and taken directly to refrigerated trucks for delivery (Figure 12). Most plants have limited facilities for storage of chilled and frozen poultry and cannot hold more than 1 day's production.

SOURCES AND CHARACTERISTICS OF WASTES

Generally, the waste of greatest pollutional significance is the blood from the killing station. Evisceration and defeathering operations contribute significantly to the waste load from poultry processing plants; receiving and packing operations contribute lesser amounts. Where live poultry are stored at the poultry plant wastes from the cleanup of manure and waste feed from the battery room represent the largest potential pollutional load originating from any single processing operation. Until a few years ago, the practice of holding live poultry in storage was quite common and the accumulation of manure and waste feed from the battery room presented a very serious disposal or treatment problem. Fortunately, under present practices, probably less than 1 percent of the total number of poultry plants provide for storage of live birds.[6]

Before a discussion of individual waste sources, it is important to differentiate between flow-away and non-flow-away processing plants. Most poultry establishments employ offal and feather flow-away systems for handling waste solids. This is one result of the recent trend toward increased automation within the industry. Flow-away systems collect wastes discarded from evisceration (Figure 13) and the feathers, dirt, and blood from the defeathering machines. The solids are screened from the flow-away waste streams at a separate location inside or outside the plant. In additon most flow-away plants pass all of their chilling and packing waters and cleanup wastes through the same screening facilities before final discharge.

Figure 10. Rocker-Type, Mechanical-Driven, Chill Tank (Left) and Ice-Pack Operations (Right)

Poultry plants without flow-away facilities put evisceration waste solids into barrels or other receptacles positioned around the evisceration table. Feathers and other solids are allowed to accumulate also on the floors and other surfaces and are gathered up by pitchfork, shovel, or other means, one or more times a day, and placed in collection barrels or other appropriate receptacles.

In the processing of poultry, the total waste product is represented by the loss from live to dressed weight plus an allowance for the water absorbed by the birds during processing. The dressed weight of poultry is determined before packing and includes some added moisture content. The term "shrinkage" defines the percentage loss from live to dressed weight. Shrinkage for eviscerated poultry varies from 24 to 28 percent for chickens[19,20,21,22,23], 19 to 24 percent for turkeys[19], and approximates 27 percent for ducks and 23 percent for geese.[19] The amount of water absorbed during processing has been reported as not generally exceeding 6 percent, however, absorbed moisture may exceed 12 percent of the dressed weight.[24]

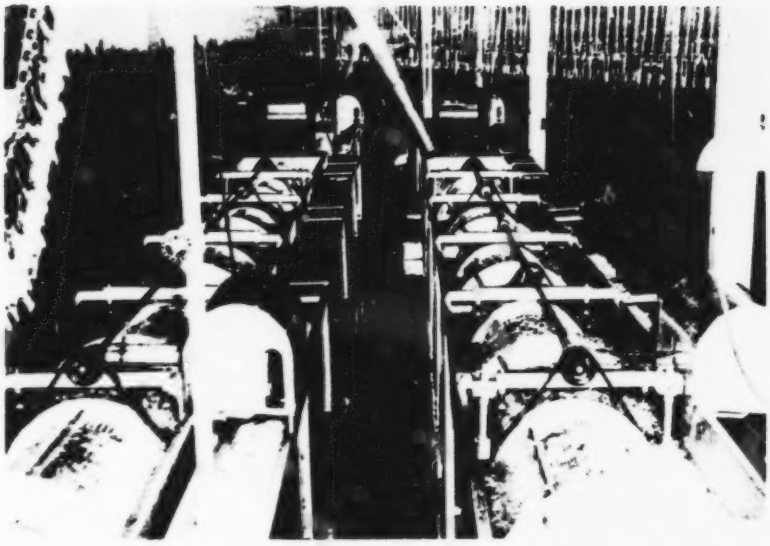

Figure 11. Continuous Chiller

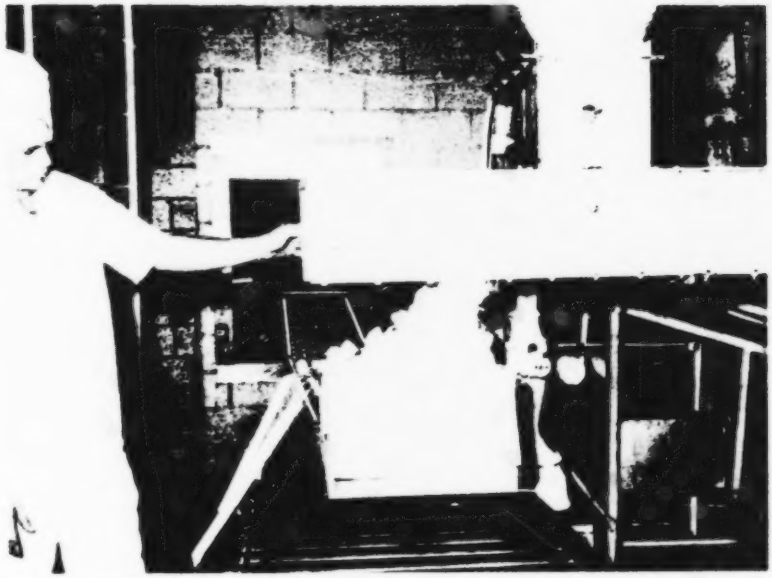

Figure 12. Icing Crate of Dressed Poultry (Ice Pack)

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Receiving of Live Birds

Manure, feathers, and dirt are deposited on the receiving area floor as the birds in coops are detained or transferred through the receiving area. If the live poultry are held only for a short time in receiving, this source of waste is of minor importance. A large amount of the manure, etc., adheres to the coops, which are returned to the poultry farm trucks, generally without cleaning.

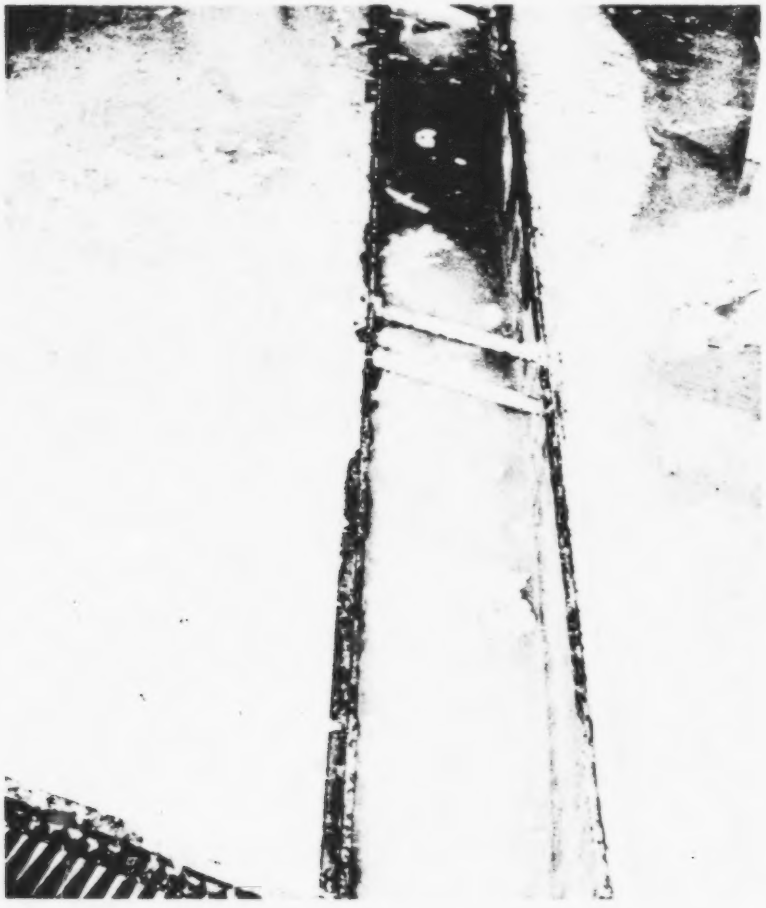

Figure 13. Offal Flow-Away Waste Conduit

A report[16] on wastes from the storage of chickens shows that the 5-day BOD* was 32 pounds and suspended solids** 35 pounds per 1,000 chickens stored each day. Another study of battery room operations[17] indicates that the wastes contained 36 pounds 5-day BOD and 40 pounds suspended solids per 1,000 chickens in storage each day. These two studies are in close agreement.

Dry cleaning of battery wastes reduces the amount of material reaching the sewer to about 5 pounds BOD and 6 pounds suspended solids per 1,000 chickens stored daily.[17] Most poultry plants fortunately remove the manure and feathers deposited in and around the receiving area by dry cleaning. This waste material is generally disposed of by dumping as refuse or is loaded onto the rendering truck receiving feathers, offal, and blood from the poultry establishment. Small quantities of water are used for hosing down the receiving area after dry cleaning, to remove residual material.

Killing

Generally blood is the waste of greatest pollutional strength in poultry processing. Feathers, dirt, and some manure are intermixed with the blood from the killing station. Most poultry establishments attempt to recover the greatest part of the free-draining blood.

Efficiency of blood recovery at the killing station depends upon the length of time devoted to draining and the method of collecting the blood. One to two minutes usually are allowed for drainage from the time the birds leave the killing station until they reach the scald tank. The shorter time is somewhat unsatisfactory in that blood is carried over to the scald tank; however, some plant operators state that feather removal is made more difficult if drainage times are too long.

*BOD, or biochemical oxygen demand, is the quantity of dissolved oxygen, generally expressed in miligrams per liter, required for stabilization of decomposable organic matter by aerobic biochemical action. This test is generally carried out for 5 days at 20°C.[18]

**Suspended solids are those solids in a liquid removed by filtration through an asbestos mat of 3 mm thickness in a Gooch crucible. The tests for suspended solids and BOD are performed according to "Standard Methods."[18]

For good blood recovery, in addition to proper draining time, the blood must be restricted to a certain area and adequately collected. Most commonly, it is permitted to congeal on the killing area floor and is removed as a semisolid once or twice a day. Another method of collection consists of metal troughs positioned below the birds to catch and convey part of the drained blood into barrels. The remainder deposits on the floors and walls. The killing area is generally an enclosed area within the plant or a "bleeding tunnel."

Some blood invariably reaches the plant sewer, even with good recovery practices. Congealed blood and other matter difficult to remove by shoveling or scraping are flushed to the sewer during cleanup. In some flow-away plants, cleanup of killing room wastes is facilitated by admixing a small quantity of feathers with the congealed blood and sweeping the gelatinous mixture into the feather flow-away floor conduit. From this point the waste is swept to the screening room and carried over the screens in metal troughs and conveyed to the truck receiving raw material for rendering. The recovered blood is generally dumped onto the feathers in the truck but may be kept in separate containers. An appreciable quantity of blood is flushed to the sewer in hosing down the killing room area, the flow-away conduit, and other exposed surfaces.

An earlier study[16] showed that approximately 8 percent of the body weight of chickens may be blood, of which 70 percent is drainable. It was further established that chicken blood had a 5-day BOD of 92,000 mg/l. The drainable blood therefore has 17.4 pounds BOD per 1,000 chickens processed.

In practice, poultry plants can salvage a good part of the blood waste in the killing area. Bolton[20] conducted a survey of five chicken processing establishments in northeast Alabama and concluded that plant BOD and suspended solids loads can be reduced by 15 pounds and 6 pounds respectively for each 1,000 birds processed if reasonable blood recovery practices are employed. Another study indicates a reduction of 14.0 pounds of BOD per 1,000 chickens by blood recovery alone.[17]

Defeathering

Liquid wastes from the picking operations include the continuous overflow and final dump from the scald tank, continuous flush-out from the defeathering machines, and wash-down from floors and equipment. Plants using wax stripping discharge a small quantity of spent wax-chilling water.

The scald tank operates on a continuous feed of approximately one-quarter to one-half gallon of hot water per bird. The overflow contains a considerable quantity of feathers, blood, and dirt.

Waste accumulated within the scald tank from the day's operation is dumped during tank cleanup. This waste, though relatively small in volume, is high in pollutional strength.

When use of water in picking operations is considered, it is necessary to differentiate between plants with and without feather flow-away. With flow-away, a continuous flow of water is needed in the waste-carrying conduit to transport feathers to the screening room. Water used to flush feathers from the line-type defeathering machines, scald tank overflow, and hose-down water are usually more than ample for providing adequate flow velocity in the waste conduit.

Poultry plants that do not have feather flow-away use little or no water in operating the defeathering machines. Feathers and dirt are trashed dry to the floor and put into barrels or other containers for separate disposal.

Feather salvage reduces the pollutional content and nuisance value of plant wastes. Where there are available outlets, feathers are sold or given to rendering plants or carried off by farmers. Where arrangements can be made with a rendering company to have its trucks available at the poultry plant, it may be advantageous for the plant to use a screw- or rake-type conveyor system for transporting feathers and offal to the truck. Bulk storage tanks, which eliminate the need for trucks standing by during the entire processing period and reduce odor and fly nuisances, can be provided for feathers and offal.

Mechanical screens must be properly operated and maintained to prevent excess spillage and overflow. There is also some drainage from the mechanical conveyor that lifts wet solids to the receiving truck or storage tank. This drainage generally flows directly to the plant sewer.

Evisceration and Cutting

Waste solids discarded at the evisceration table consist of feet; heads; inedible viscera; crop and windpipes; grit, sand, and gravel from the gizzard cleaning operation; flesh trimmings; fat; grease; blood; and some miscellany. Lungs, if removed by hand, are discarded at the table also; however, if they are removed by suction, the lungs are generally transferred to a lung storage tank and released to flow-away further down the line. Discharging the contents of the lung storage tank into flow-away may create a problem at the screening unit since this particular material, gelatinous and stringy in consistency, has a tendency to clog the screening facilities. Cut-up operations increase the amount of flesh trimmings, fat, and grease in eviscerating room wastes.

The offal waste flow-away conduit (Figure 13) receives all the waste solids and wash water from evisceration and cut-up, and

these wastes constitute the major portion of total waste flow from a poultry plant. The open water taps used for cleaning the various poultry segments on the evisceration table are the largest contributors to the volume of water carried in the offal flow-away. This flow is augmented by sprays from the outside and inside carcass washers, by the frequent hosing down of the evisceration room floors, and by wash water from cut-up. The entire offal flow-away is screened before final discharge.

The small number of poultry plants without offal flow-away put most of the waste solids from evisceration and cut-up into barrels placed alongside the evisceration table. In this type plant, all wash water from evisceration and cleanup is discharged directly to the plant sewer. Previous studies[16] have indicated that if waste solids are collected in separate containers at the evisceration table the expected discharge from evisceration will contain 6 to 8 pounds BOD per 1,000 chickens processed. Grease in the waste may impose a burden upon subsequent waste treatment.

Recovered offal is handled in barrels or as bulk. Offal generally is sold as raw material for rendering or processing into animal and poultry feed, but occasionally is dumped and buried.

Packing

Waste from packing operations consists of overflow of water and ice from the chilling of whole birds and individual segments. Since the U. S. Department of Agriculture requires a minimum overflow of 0.5 gallons per bird for quick chilling, it is expected that the total waste discharge from packing for most poultry plants should not greatly exceed this figure.

The chilling water, whether it originates from the large mechanically driven units or from the portable-type vats or tubs on the floor, contains some fat, bits of flesh, and other solids. In most cases this waste is of low pollutional strength. Cleanup of floors and equipment results in a low-volume, weak waste that is handled along with the chill waters. Chilling and cleanup liquors are discharged to the flow-away screen or, in the absence of flow-away, are released directly to the plant sewer.

Miscellaneous

In large plants mechanical conveyors in the screening room are used to transport the screened solids directly to a receiving truck. Some poultry plants store feathers and offal in separate, elevated hoppers located outside the plant to provide flexibility in scheduling receiving trucks. Drainage from the storage hoppers is an additional source of waste. In the event of tank leakage, the strong liquors from the storage bin drain out and usually end up in the plant outfall sewer.

No information concerning detergents in poultry processing wastes is available. Most poultry plants use appreciable quantities of detergent compounds for scrubbing or washing down equipment, floors, walls, and other surface areas within the plant, and this cleanup waste subsequently reaches the plant sewer.

TOTAL PLANT WASTES

The characteristics of poultry processing wastes are quite similar to wastes from red meat slaughtering and processing operations. Waste flows and pollutional characteristics depend upon the manner in which blood, feathers, and offal are handled; the degree of pretreatment at the plant site; the type of processing equipment available; and the attitude of the plant operators in regard to water conservation and pollution abatement.

Poultry wastes may be divided according to the period in which they are produced, i.e., during processing or cleanup, since there are differences in the quantity and pollutional content of the wastes produced during these periods. Bolton[20] studied four poultry plants with feather or offal flow-away and found that about 75 percent of the daily volume, BOD, and suspended solids were discharged during processing. A nonflow-away plant discharged about 60 percent of its daily volume, BOD, and suspended solids during processing. A flow-away plant releases more waste during processing, because with the convenience of a flow-away system, most of the discarded solids are flushed to the waste conduit as they are produced.

The normal ranges in the composition of poultry plant wastes are compiled in Table 3. Day-to-day variations in the pollutional strength of wastes from any one plant are great, but variations from plant to plant are greater. Poultry establishments without flow-away generally have a lesser unit-waste volume, but the effluent has a proportionately greater pollutional strength.

Poultry wastes have a high ratio of volatile to total solids, indicating that they are predominately organic in character. Although there is more dissolved matter than suspended matter in the liquid waste, the appreciable quantities of settleable solids normally found indicate that settling is a reasonable means for providing partial treatment of these wastes. Washing compounds increase the pH and alkalinity levels of plant wastes, particularly during cleanup.

Table 4 is a compilation of waste loadings from 13 chicken processing plants. Sampling at these plants consisted of grab samples taken throughout the day at regular intervals varying from 15 minutes to 1 hour and composited according to presumed flow. The number of sampling days varied from 3 to 16. All plants at the time of study dressed out only eviscerated poultry. These establishments had no battery room facilities and consequently no waste from this source. The plants were divided into appropriate categories based on availability of flow-away and method of handling blood wastes from the killing room. The unit values in Table 4 may be used to provide reasonable estimates of the waste loadings from the various types of poultry plants.

Table 3. COMPOSITION OF COMBINED POULTRY PLANT WASTES

	Range
Five-day BOD, mg/l	150-2,400
COD, mg/l	200-3,200
Suspended solids, mg/l	100-1,500
Dissolved solids, mg/l	200-2,000
Volatile solids, mg/l	250-2,700
Total solids, mg/l	350-3,200
Suspended solids, % of total solids	20- 50
Volatile solids, % of toal solids	65- 85
Settleable solids, ml/l	1- 20
Total alkalinity, mg/l	40- 350
Total nitrogen, mg/l	15- 300
pH	6.5- 9.0

Table 4. PROCESSING PLANT WASTE LOADS PER 1,000 CHICKENS

Type of plant	No.	Waste, gallons	BOD, pounds	Suspended solids, pounds
Flow-Away	10	7,000[a]		
With blood recovery	5	-	25	13
All blood wasted	5	-	41	23
Nonflow-Away	3	4,500		
With blood recovery	1	-	23	12
All blood wasted	2	-	35	21[b]

a. Present trend in sanitation practices is towards greater water use. Current operating data indicate average water use of about 8,000 gallons per 1,000 birds.

b. Estimated.

There is a trend toward use of more water in the modern poultry plant. This is a result of greater water use in product and plant sanitation and U. S. Department of Agriculture requirements, which increased minimum volumes for chilling of poultry. Nonflow-away plants may be expected to use about 4,500 gallons of water for each 1,000 birds processed. Data in Table 4 show that flow-away plants use an average of 7,000 gallons per 1,000 birds; however, recent practice indicates that 8,000 gallons per 1,000 birds is a more realistic value.

For flow-away plants with and without blood recovery, average BOD values of 25 and 41 pounds per 1,000 chickens respectively, are virtually identical to the unit BOD loads suggested by Bolton.[20] The nonflow-away plant, with reasonable recovery of solids at the picking room and evisceration table, will average a BOD load of only 23 to 35 pounds per 1,000 chickens, depending upon degree of blood recovery. In nonflow-away plants, wastes from the evisceration room alone (with solids recovery) range from 6 to 8 pounds BOD per 1,000 chickens.[16]

The suspended solids from flow-away plants averaged 13 pounds per 1,000 birds, with blood recovery, and 23 pounds, without blood recovery. Suspended solids from nonflow-away plants averaged slightly less, 12 and 21 pounds, respectively.

Few data are available regarding wastes from the processing of poultry other than chickens. This points up the need for study of other types of poultry processing establishments. It is suggested that for turkeys, ducks, or geese Table 4 values be multiplied by a factor based on relative weights to obtain rough estimates of waste loads. The average weight of chickens processed in 1960 was 3.48 pounds.

POLLUTIONAL EFFECTS OF POULTRY WASTES

Principal deleterious effects of untreated or inadequately treated poultry wastes upon receiving waters are reduction of oxygen content, if dilution is inadequate; deposition of solids as offal, feathers, bits of flesh, heads, feet, grit, feed, manure, and even at times whole birds; addition of floating solids, primarily feathers and grease; increase of coliform and pathogenic organisms; increase of color and odor; and enrichment of the stream by addition of inorganic nutrients.

Sludge banks formed by the deposition of settleable solids may cause offensive odor, unsightly conditions, and eradication of macrobenthic bottom life in a body of water. Feathers and grease greatly detract from the aesthetic quality of receiving waters. Color, primarily from blood, presents visual pollution. Excessive amounts of inorganic nutrients released to the stream may be responsible for algal blooms and associated problems.

Municipal treatment facilities that receive relatively large quantities of poultry wastes may experience difficulties, caused by the high BOD, solids, and hydraulic loads of the wastes. Inadequate control in the processing plant contributes to these difficulties and others within the sewage treatment plant. Feathers, grease, and other waste solids can clog sewers, screens, pumps,

sludge lines, filters, spray nozzles, and other equipment. Putrescible grit and feed will settle out in the grit chamber unit of the treatment plant. Odors may be widespread when the treatment facilities are overloaded or when solids removed from the inflow are not disposed of promptly. Material caught in the trickling filters undergoes decomposition, with accompanying obnoxious odors.

Rising sludge on the secondary settling unit at some plants is particularly associated with the handling of poultry wastes. An increase of the sludge return rate to the primary settler appears to alleviate this problem.

Within the digester, the grease content of the sludge may build up to a point where the sludge rises rather than consolidates at the bottom. Feathers are also troublesome since they are fairly resistant to anaeobic degradation and cause matting of the scum layer. Mechanical or gas mixing of the digester contents prevents scum formation and improves digestion.

MEASURES FOR THE REDUCTION OF POLLUTIONAL LOAD

Good housekeeping, efficient waste recover, and modifications in processing reduce the quantity of wastes from a poultry plant. It is more economical to reduce the wastes as much as possible at the source than to treat the gross wastes. Treatment is then provided for the residual material.

Poultry wastes most commonly are discharged to municipal treatment facilities, since these facilities provide the most economical and troublefree means for disposal and relieve the industry of technical problems associated with waste treatment. In most plants, poultry processing effluents discharged to municipal sewerage facilities are screened at the poultry plant. Screening is an essential part of the flow-away system.

When public sewerage is not available, the necessary treatment must be provided at the poultry plant site.

Good Housekeeping, Recovery and Operational Changes

Receiving Area

Dry scraping and cleaning of the manure, feathers, dirt, etc., form the receiving area floors are good plant practices and insure that feathers and gross solids from this source are excluded from the plant sewer. Dry cleaning of the receiving area floor reduces the waste load from 1.0 pound BOD and suspended solids to 0.2 pound per 1,000 chickens processed.[17] Where live poultry are held in storage, dry cleaning of the batteries and battery room should be practiced.

Killing Station

Killing and bleeding operations should receive special attention if total plant pollutional load is to be reduced to a minimum. Most of the free-draining blood can be recovered if drainage time is carefully controlled, blood wastes are restricted to a given area, and good waste collection and removal techniques are used.

Careless cleanup procedures and loss of blood into floor drains left open during killing account for much wasted blood. During cleanup, the maximum amount of blood should be shoveled, scooped, scraped, or swept from floors, walls, and other surfaces before they are hosed down. One plant observed uses a "vacuum cleaner" device for recovery of congealed blood from the killing area floor. The efficiency of this collection method has not been evaluated, but it apparently is rapid and convenient.

Blood recovery normally is economical, since the blood may be sold as rendering material, fish bait, or mink food, or may be offered in exchange for removal from the plant. In 1956, the U. S. Department of Agriculture[19] reported that in a survey of 343 poultry plants, 169 saved blood. Of the latter, 22 quoted prices they were receiving for blood; most of these prices ranged up to 50 cents per gallon. After a study of plants in Delaware, Kaplovsky[25] in 1958 estimated that blood reclaimed from the processing of 60,000 chickens per day could provide a return of $235 per month, in addition to saving cost of treating this waste.

Picking Room

Feathers are the principal waste produced in the picking room. Because of difficulties in handling great quantities of feathers, considerable amounts frequently escape with the plant effluent.

Extreme care should be exerted to assure maximum recovery of feathers at the flow-away screens or in the picking room. A higher degree of recovery is possible if this waste is collected at the latter point. The recovered feathers may be sold to rendering plants or given to farmers; in some cases the renderer will remove the feathers in exchange for the feathers.

In 1956[19] the U. S. Department of Agriculture stated that of 343 poultry plants surveyed, 58 percent reported that feather wastes were turned over to rendering plants or farmers. Although rendering plants are the most common feather outlet for poultry establishments, they require large volumes of raw material for economical operation. Proximity to the renderer and the ability of the poultry plant to supply large quantities of feathers determine the price. In 1955 about one-third of the renderers paid for the feathers they received from poultry plants;[19] most reported prices were from $2.00 to $4.00 per ton for feathers removed from the poultry plant and approximately $8.00 for those delivered to the rendering plant. It was estimated that a Delaware poultry plant, processing 60,000 chickens per day in 1958, could expect to re-

ceive a monthly income of $3,200 for feathers recovered and sold to a nearby rendering plant.[25] The market fluctuates widely, however.

Flow-away screens for feathers and offal, even under the most efficient operating conditions, cannot remove all solids from the waste stream. There are common troubles associated with the operation of the various types of flow-away screens. Rotary screens used for feather flow-away may become matted with feathers, although this problem can be alleviated by jetting water sprays on the screen.[20] The tendency for feathers and offal to ride up the sides of the rotary screen before falling into the collection barrel can be overcome by attaching a flared funnel to the depositing end of the screen. In practice, the mechanical screens frequently become overloaded or clogged, resulting in overflow or by-passing of the waste stream. Solids discharging from the screens often spill onto the floor because the collection barrels are not replaced in time. The careless removal of back-up stationary screens or failure to remove trapped solids from behind the protective baffles permits the escape of considerable solids to the outfall sewer.

Many poultry plants use more water than necessary. The amount of water used in defeathering, evisceration, and flow-away systems should be reasonable but not excessive. Recirculation of feather or offal screen underflow back to the feather flow-away system will conserve water. Bolton[20] observed that total plant waste volumes could be reduced as much as 30 to 40 percent by recirculation of feather screen underflow. Flow in the flow-away system should be kept at a minimum consistent with good sanitation.

Evisceration Room

Waste solids originating from eviscerating room operations are somewhat easier to handle and collect than blood and feathers. Screening facilities for offal flow-away are very similar to those used for feather flow-away. Lung wastes should be collected separately and retained for disposal with offal. Substantial quantities of grit and feed wastes originate in the gizzard station.[20] A very fine mesh screen should be used to keep these wastes from escaping through the flow-away screen.

The by-product produced in greatest quantity in the evisceration room is offal, for which in some areas there is considerable demand. A U.S. Department of Agriculture survey in 1955[19] indicated that of 343 poultry plants studied, 274 supplied offal to rendering plants and farmers; 125 of these poultry plants were paid up to $0.74 per 100 pounds of offal. Although the renderer or farmer in some areas will not pay for the offal, he will bear the cost of removal from the plant. Since the larger poultry plants generally are dependable sources for large quantities, they can

sell offal for rendering purposes. Data from 1958[25] indicated that a plant processing 60,000 chickens per day could expect a monthly return of $1,550 if a rendering plant was available for receiving the recovered offal.

Floor Drains

Floor outlets should be made inaccessible to wastes in waste recovery areas. These outlets should be open only during the final stages of cleanup. In a flow-away plant, however, floor drains generally discharge to the flow-away screens, and only large solids must be prohibited from entering individual drains. A suitable metal grid or other means of covering the floor outlets stops the flow of large solids to the flow-away conduits.

Floor drains within nonflow-away plants should be covered with metal grating or perforated metal plate. Coarse screens should be inserted in the conduits to further entrap solids. The screens should be readily accessible for cleaning, but may be welded in place to guarantee that they are not removed as removal would permit solids to be flushed to the plant sewer.

WASTE TREATMENT

The type and degree of poultry waste treatment generally depends upon the cost of using an available municipal treatment plant, the cost of constructing new treatment facilities at the poultry plant site, and the allowable use of the receiving stream. Most of the information on treatment of poultry wastes necessarily was derived from chicken processing plants; however, wastes from the processing of other species of poultry should behave similarly.

Separate Treatment of Poultry Wastes

Pretreatment by Screening

Screens should precede all subsequent forms of waste treatment and provide for removal of the coarser settleable, floating, and suspended material. They may be of the stationary, rotary, (Figure 14) vibrating, or centrifuge type, mounted vertically, horizontally, or sloped to any desired angle. The size of the openings in the screening varies from 0.5 inch to 0.0025 inch (approximately 200 mesh).

Flow-away plants pretreat feather and offal flow-away wastes by passing each through fine-mesh mechanical screens, sometimes followed in series by one or more coarse stationary screens (Figure 15). A mechanical, rotary, or vibrating 20-mesh or finer screen is commonly used as the first unit in the series (Figure 14). The stationary units serve primarily to protect against spills,

overflows, and other similar occurrences. One screening arrangement that has been used successfully consists of a trap equipped with two or more one-quarter- to one-half-inch-mesh screens, mounted vertically and in a series following the mechanical screen (Figure 15). Baffles may also be used, preceding the stationary screens.

There is a serious lack of available information on the performance of fine-mesh screens. Reliable operating data are needed on the efficiency of various sizes and types.

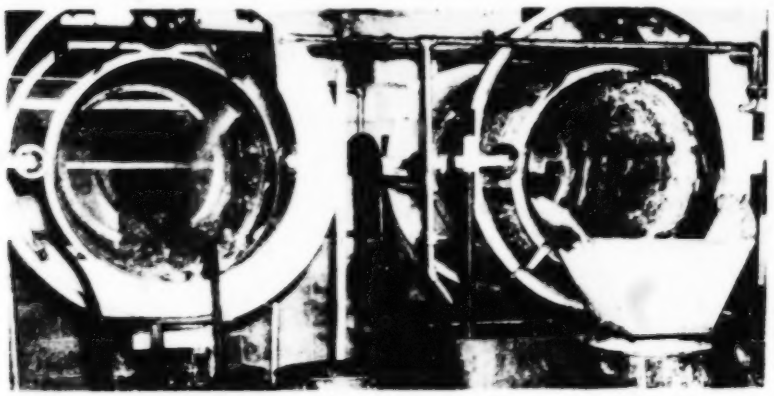

Figure 14. Rotary Screens: Offal (Left) and Feathers (Right). Feather screen effluent is recirculated from sump to transport feathers.

Grease Removal

All poultry plants discharge a quantity of grease. The grease problem may become critical where large numbers of birds are processed.[19, 26]

Where primary treatment facilities are available, grease may be adequately removed together with other floating material by use of appropriate skimming and collecting devices in the primary sedimentation basin. Since most poultry plants do not have primary treatment, however, grease traps are sometimes used. These traps provide adequate removal of grease but often are a source of trouble, primarily from lack of operator attention. Air flotation is practicable for the removal of suspended solids, grease, and particles of flesh, particularly where the floating material may be rendered for yield of valuable by-products.[13]

Primary Treatment

In primary treatment, the settleable and floating materials are separated in sedimentation tanks. The sludge and scum require additional handling such as digestion, burial, drying, or lagooning.

Figure 15. Stationary Screens Employed as Overflow Protection for Mechanical Screening Operation

Solids settling rates and sludge volumes may be determined from preliminary laboratory tests.

At the present time there is a lack of data regarding primary treatment of poultry wastes. Reference is made, however, to two laboratory studies. Separate experiments[27] on killing room, picking room, and packing room wastes from New York Pack op-

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erations of three plants showed that an average of 28.1 percent BOD removal and 64.1 percent suspended solids removal could be expected from settling. The other investigation[21] was on combined wastes from a flow-away plant processing eviscerated pack. Settling efficiency was low; BOD and suspended solids reductions were 17 and 30 percent, respectively.

Trickling Filter and Activated Sludge

The trickling filter or activated sludge process can be used for treatment of poultry wastes. These methods have not received wide application, however, because of relatively high construction costs and exacting operational requirements.[23]

Screening, settling, and equalization of flow are essential for the proper functioning of the biological units. These units convert nonsettleable waste components remaining from primary treatment into settleable sludge and oxidized end products. The excess sludge from secondary settling is generally admixed with primary settled sludge, and the combined sludge removed and digested under anaerobic conditions.

During weekends or other periods when there are no processing operations at the poultry plant, it may be necessary to provide recirculation in the biological units, using treated waste water, if available. These units would otherwise be "resting" and appreciable quantities of active microbiological life could be destroyed. Intermittent waste loads such as those occasioned by partial-week operation of the processing plant militate against use of trickling filter or the activated sludge process.

A trickling filter or activated sludge plant should remove from 75 to 95 percent of the BOD and from 90 to 95 percent of the suspended solids from poultry wastes. Sand filtration or other supplemental treatment may follow secondary settling where a more highly purified effluent is necessary. Chlorination of the effluent may be required in many instances.

There has been only one instance reported of a poultry plant using either trickling filtration or activated sludge for separate treatment of its wastes.[28] This establishment employed high-rate trickling filtration for treating a daily waste volume of 120,000 gallons containing about 220 pounds of BOD. Approximately 80 percent BOD removal was obtained.

Extended Aeration

Extended aeration is a modification of the activated sludge process.[29] The process utilizes long-term (24 hours or more) aeration of sewage in the presence of activated sludge, followed by settling of the mixture in a settling tank. The supernatant is discharged, and the settled sludge is returned to the aerator. Sludge-holding tanks for removal of excess sludge may be necessary. Stabilization ponds may be needed for polishing the effluent where downstream water uses require this protection.

Extended aeration is currently being used to treat wastes from a chicken plant in Hiddenite, North Carolina. This plant processes about 10,000 birds per day or 40,000 per week.[13] It was designed to treat wastes from the processing of 80,000 birds per week. Feathers and offal are mechanically screened in a flow-away system and blood is not recovered. Unit waste factors were reported as approximately 6,000 gallons of water, 33 pounds BOD, and 20 pounds suspended solids, per 1,000 birds. The average BOD load ranged from 305 to 358 pounds per day. It was reported that treatment provided 90 percent BOD removal and 79 percent suspended solids removal. The effluent contained around 67 mg/l BOD and 82 mg/l suspended solids. No solids had been wasted from the aeration chamber in 7 months of operation. The only operational difficulty reported was the buildup of feathers and other solids as a mat at the effluent end of the aeration basin. This material was removed by pitchfork or withdrawn through the surface scum take-off pipe. This process appears promising and should be studied and evaluated further.

Stabilization Ponds

Most commonly, stabilization ponds are used to treat poultry wastes in combination with domestic sewage, although often they are used for separate treatment of poultry wastes. The ponds require large tracts of land, generally isolated from sizeable population areas.

Design data for ponds receiving combined poultry and domestic wastes in Arkansas, Mississippi, and Alabama indicate 5-day BOD loadings approaching 50 pounds per acre per day. According to the most common standards, rates of application for municipal sewage range from a low of 20 pounds BOD per acre per day in the Dakotas[30] to a high of 100 pounds BOD per acre per day in the South.

Stabilization ponds properly loaded and operated may be expected to provide 70 to 95 percent reduction in BOD. Poultry processing wastes should be screened prior to discharge to stabilization ponds. At high organic loadings, undesirable odors may develop. Under these conditions, nitrate salts may be added to the pond to supply additional oxygen. Proper surveillance should be provided and remedial measures taken if necessary, to insure that stabilization ponds do not become a breeding place for mosquitoes and other insect pests.

A detailed description of pond treatment facilities at a chicken plant in Indiana has been reported.[22] The wastes resulting from New York dressed and eviscerated processing were initially screened and then passed through a settling or "septic" tank with

about 12 hours holding time. They were then retained in a pond having approximately 11 days theoretical holding time. The entire flow seeped through an underlying gravel stratum. Determination of the treatment efficiency during a typical day of operation in June indicated that the initial screening (one-quarter-inch mesh) plus settling removed about one-half of the BOD and suspended solids from the wastes. The 300,000-gallon, 12-foot-deep pond was loaded at a relatively high rate, but samples taken from the pond showed that 81 percent of the inflow BOD was removed. Calculations based on information given in the report indicate that the pond loading was around 150 pounds BOD per acre per day. Because of the high loading, ammonium nitrate was added at a rate of 140 pounds per week in the summer and 35 pounds per week in the winter for the control of odors.

Spray, Ridge and Furrow, and Flood Irrigation - Land Application

The treatment and disposal of poultry processing wastes by land irrigation, particularly spray irrigation, is gaining favor, especially for the smaller poultry plants in semi-isolated areas. One rule of thumb states that approximately 55 acres of land should be available for each 50,000 birds slaughtered weekly, although more acreage is desirable.[31] Where sufficient land is available, low capital costs and simplicity of operation and maintenance make this treatment method advantageous.

Wastes should be settled or at least screened to avoid clogging of spray nozzles and deposition of solids in the distribution lines. The design of irrigation facilities must take into account soil characteristics, cover crop in regard to absorption and transpiration capacity, climatic conditions, topography, and location of ground water table. Care should be taken not to contaminate ground waters used as a source of water supply.

Sufficient acreage is required so that the soil can dry out at regular intervals to allow penetration of oxygen and nitrogen to the roots of the cover crop and penetration of oxygen to the soil bacteria. Ridge and furrow systems may develop odors and insect infestation because of accumulation of solids within the furrows.[31]

There are reports of three irrigation systems for the separate treatment and disposal of processing wastes. One poultry plant in Arkansas[28] sprayed 20,000 gallons of waste per day, after screening and equalization, onto sandy-loam soil at the rate of 60 inches per year. Entire equipment costs amounted to $1,800, and operational and maintenance costs were in the range of $1,500 to $2,500 per year. There were no detectable odors reported from the irrigation site. Another chicken processing establishment in Arkansas[32] utilized 14,000 to 22,000 gallons per day of screened and settled plant effluent for flood irrigation. The liquid wastes were applied to a tight clay loam soil, relatively low in absorption capacity. Dosing rates ranged from 6 inches per year during the winter to 10 inches per year in the summer. Equipment costs

were approximately $1,000, and operational and maintenance costs ranged from $2,000 to $3,000 per year. Little or no odor was reported.

A ridge and furrow underdrained irrigation system covering 1.05 acres was installed by a chicken plant in Wisconsin[32] to treat 60,000 gallons of waste per day, 4 days a week. The treated effluent was clear even though the liquid in the furrows was quite red. A single grab sample taken from the tile drains in November of 1957 contained only 5.5 mg/l of BOD. Accumulation of feathers and other solids in the furrows indicated the need for improved screening.

A U. S. Department of Agriculture publication[31] outlines anticipated costs for spray irrigation, exclusive of land costs, for various sizes of poultry plants. For example, a plant processing 180,000 pounds live weight of poultry per week will have an initial investment of around $3,300. Annual fixed costs for equipment, plus interest and depreciation, would be approximately $640. In addition, the annual costs for power and labor should range between $1,350 and $3,200. For a plant processing 360,000 pounds live weight of poultry per week these costs should be about $6,100, $1,200 and $2,300 to $5,100 respectively.

Sand Filtration

The results of laboratory bench studies[27, 33] have indicated that sand filtration is not generally suitable for the treatment of poultry processing wastes. In addition to high construction costs and the need for large land areas, it was found that sand filters are rapidly clogged by feathers and other solids.

Chemical Treatment

In 1957, the North Carolina State Board of Health[21] undertook a survey of wastes from a flow-away system in a plant processing eviscerated pack chickens at Dobson, North Carolina. Part of the laboratory work was an investigation of chemical coagulation as a potential means of treatment. In combinations with lime, alum and ferric chloride were used separately as coagulating agents on composite samples of wastes. Analytical determinations taken on the supernatant after 30 to 60 minutes of settling indicated approximately 65 percent reduction of BOD and 60 percent reduction of suspended solids. The report states that alum coagulation was more efficient, and that 650 pounds of alum and 150 pounds of lime would provide the indicated treatment for each one million gallons of poultry waste. Generally, chemical treatment is expensive and not too effective.

Chlorination

Chlorine is applied to treatment plant effluents principally to destroy bacteria and pathogenic organisms prior to discharge of effluents to receiving waters. A minimum chlorine contact time of 15 minutes at maximum flows is required for adequate disinfec-

tion.[34, 35] Under these conditions, chlorine residuals should range from about 0.2 to 1.0 mg/l,[34] although sufficient chlorine capacity to produce a minimum residual of 2.0 mg/l has been recommended.[35] Chlorine may be used for the control of odors at various locations within the waste treatment plant.

Poultry Waste Treatment by Municipal Plants

In most cases poultry plants can best solve the waste disposal problem by discharging to municipal treatment facilities. The industry thus is relieved of the technical responsibility related to treatmert of the waste.

Bolton[20] described a critical aspect of community-industry relationships when he reported, "... processing plants usually locate in small rural towns where existing water and waste treatment facilities are in many cases already inadequate." A typical example is the case of a small town that attracts one or two fair-sized poultry processing plants. More often than not, the waste loadings from these poultry plants will immediately exceed the municipal treatment reserve that had been considered feasible for industrial expansion.

In the design of new or expanded municipal treatment facilities, adequate allowances should be made for poultry wastes. Design criteria should include both the peak and average daily loadings; a discharge period of 16 hours is a reasonable basis for design. Possible expansion of the poultry plant must be considered.

According to Bolton[40] an 8,000-gallon flow and 25 pounds of BOD per 1,000 birds are used as bases of design for 16-hour-per-day operation of a poultry processing plant. The hydraulic load is based on the assumption that 6 gallons per bird is used during the kill period and 2 gallons during cleanup. For example, an 8,000-bird-per-hour operation would require 48,000 gallons of water per hour, or a design capacity rated at 1.15 mgd. The total organic load (BOD) from the processing plant would be the hourly rate extended over 16 hours, or 3,200 pounds per day.

Trickling Filter Plants

Trickling filtration is commonly used where it is known that large quantities of poultry wastes are to be treated along with domestic sewage. Double-stage filtration is more effective than single-stage.

The liquid wastes from eight chicken processing establishments located in Gainesville, Georgia, are added to the municipal system and treated by the city's two sewage treatment plants. The older of the two installations, a high-rate trickling filter plant, is presently receiving near capacity daily loads. Treatment efficiencies appear to be approximately the design estimates, 60 to 65 percent BOD removal and 80 to 85 percent suspended solids removal. The major portion of total daily wastes to the treatment plant is contributed by the various poultry plants. When the poultry plants are processing, the treatment plant is overloaded, resulting in decreased efficiency and maximum operational difficulty.

The newer municipal treatment plant at Gainesville, Georgia, and another at Albertville, Alabama, employ double filtration. The Albertville plant uses pre-aeration and two-stage filtration with intermediate clarification. It is believed that pre-aeration of poultry wastes greatly improves over-all treatability. Both the Gainesville plant, which is rapidly approaching design loadings and the Albertville installation are apparently operating effectively.

Activated Sludge Plants

Many communities treat combined domestic and poultry wastes by the activated sludge process. Activated sludge treatment of large quantities of combined poultry wastes and domestic sewage has been studied.[36] The treatment plant served a domestic population of 4,000 and treated poultry wastes with average BOD and suspended solids populations equivalents of 1,500 and 1,3000 respectively. No data were reported on treatment performance.

Miscellaneous

Even with the most effective screening at the processing plant, some feathers are lost and reach the treatment plant. Over a period of time they will accumulate in the digester and particularly in the scum mat and cause much difficulty in operation, since feathers are not readily digested in the time usually provided.

Bolton[40] has found that the use of mixing equipment of the "draft tube" type provides a positive breakup of the scum mat and with improved mixing greatly reduces difficulties associated with this problem.

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